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Abstract

EXPERIMENTAL WORK ON NEUTRON THERMALIZATION

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The paper reviews the experimental work on neutron thermalization which has been carried out in recent years in the Kurchatov Atomic Energy Institute. This work deals with the most interesting aspects of neutron thermalization which have practical importance, and is carried out along three lines.

1. Investigation of inelastic scattering of slow monochromatic neutrons on bound nuclei of the moderator.

In connection with this line of research the review gives the results of double differential scattering cross-sections of slow monochromatic neutrons $\sigma(EE'\theta)$ in hydrogen-containing moderators. A pulsed flux of monochromatic neutrons of energy E incident on the sample was separated from the horizontal beam of thermal neutrons of the VVR-M reactor (Physics Institute of the Academy of Sciences of the Ukranian SSR) with the aid of a mechanical monochromator. The resolution of the monochromator was independent of its speed of rotation and was equal to $\frac{\Delta E}{E} = 0.2$. The energy E' of neutrons scattered from the sample at an angle θ was measured by the flight time method with a resolution of about 25 μsec/m.

The double differential scattering cross-sections were measured within the range of energies of the incident neutrons from 15 to 300 eV at scattering angles from 15° to 120°. Certain data were obtained concerning the effect of the sample temperature on the double differential scattering cross-section.

The comparative analysis of the cross-sections and average characteristics of neutron scattering in water and monoisopropyldiphenyl ($C_{15}H_{16}$) shows that the chemical binding of the hydrogen in monoisopropyldiphenyl is stronger than in water and, accordingly, the neutron thermalization in monoisopropyldiphenyl proceeds at a slower rate.

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The law of scattering $S(\alpha,\beta)$ and the generalized frequency spectrum for water and monoisopropyldiphenyl were obtained from the experimental data.

2. Investigation of the establishment of the thermal neutron spectrum in time in various moderators.

The establishment of the thermal neutron spectrum was studied with the aid of a pulsed neutron source and a mechanical chopper. Neutrons were produced on a target of a linear accelerator which operated in phase with the mechanical chopper. Neutron spectra were measured in beryllium and graphite at different time intervals after fast neutron burst. The resolution during measurements was 3 to 5 μsec/m, the duration of the neutron pulse furnished by the mechanical chopper, 5 to 10 μsec.

3. Investigation of thermal and slowing-down neutron spectra in homogeneous and heterogeneous media.

Microbeams of neutrons were extracted from the medium under investigation. The neutron spectra in the beams were studied with the aid of a mechanical chopper using the time-of-flight method. The resolution during the measurements of the thermal part of the spectrum was 10 to 25 μsec/m, during the measurements of the slowing-down spectrum, 1.2 μsec/m. Spectra of thermal neutrons in boron-poisoned water were studied at various boron concentrations.

A detailed investigation was made into the space-energy distribution of neutrons in the cells of subcritical lattices: uranium-water, uranium-monoisopropyldiphenyl, uranium-graphite.

The measurement results indicate that the thermal neutron spectrum in water can be described by the Maxwell distribution with the temperature of the neutrons exceeding the temperature of the media. At the given temperature of the moderator the temperature rise of the neutrons is proportional to absorption.

The spectrum of thermal neutrons in the uranium block of a lattice and also in a moderator differs from equilibrium Maxwell distribution. The nature of the neutron spectrum abruptly changes at the boundary between uranium and moderator. Inside the block and the moderator the neutron spectrum changes but little. A simple semi-empirical relation is given between the thermal neutron spectrum in the block and in the moderator. The spectrum of the slowing-down neutrons in the block has peculiar dips at energies corresponding to the known absorption levels of U^{238} and U^{235}.